Report from the judges, Australia 2017

The IMMC 'jet lag' problem

The 'jet lag' problem set for the 2017 challenge began: "Organizing international meetings is not easy in many ways, including the problem that some of the participants may experience the effects of jet lag after recent travel from their home country to the meeting location which may be in a different time-zone, or in a different climate and time of year, and so on. All these things may dramatically affect the productivity of the meeting."

Student teams were tasked with creating an algorithm to produce a list of recommended places to hold a meeting, with the aim being to maximise overall productivity. They were asked to test their algorithm on two datasets:

Scenario 1 "Small Meeting". Time: mid-June. Six individual participants from: Monterey CA, USA; Zutphen, Netherlands; Melbourne, Australia; Shanghai, China; Hong Kong (SAR), China; Moscow, Russia

Scenario 2 "Big meeting". Time: January. Eleven individual participants from: Boston MA, USA (2 people); Singapore; Beijing, China; Hong Kong (SAR), China (2 people); Moscow, Russia; Utrecht, Netherlands; Warsaw, Poland; Copenhagen, Denmark; Melbourne, Australia.

The modelling process

An essential starting point is to clarify exactly what the IMMC problem required. The problem statement asks teams to develop an algorithm and test it on at least two given scenarios. It is worthwhile emphasising that the question does not ask where those two meetings should be held, but asks for a systematic process (an algorithm) that could be followed to determine a location for a meeting of participants from different home locations that maximises productivity of the participants, especially in relation to the effects of jet lag.

A further essential step in an effective modelling activity is to transform the statement of what is required in relation to the problem statement and its real-world setting, into a mathematical objective. As well as developing a clear understanding of what would constitute an answer to the question in the context from which it came, the goals of the exercise must also be expressed in clear mathematical terms. For example, the mathematical objective could be to minimise total distance travelled by the meeting participants, or time spent travelling, and so on.

The end-point of the modelling process is to communicate the results of the modelling work in a form that can be understood and used by its intended audience. The form of the product required for the IMMC comprises three parts: a one-page summary sheet, a report of the solution, and appendices including references used. However, the exact way a report is constructed should be determined in light of its purpose and audience. A modelling report is not the same thing as a school mathematics assignment. It might

often take the form of a recommendation or set of recommendations to a committee, together with an explanation and justification of the recommendations.

In between the beginning process of defining the goals of the task and defining that in mathematical terms, and the end process of writing a report, the processes of model formulation, mathematical processing, and model evaluation take place. Those processes would often occur multiple times, since a first attempt at solving the problem might expose further issues that should be taken more effectively into account to provide the best possible solution to the problem at hand. A better mathematical formulation might be needed, an adjusted model might then be required, a different kind of mathematical processing could assist, and an updated interpretation of the results and evaluation of the outcomes would then be needed.

Approaches taken by Australian teams

The remainder of this report provides commentary on observations made from the reports submitted by Australian teams in the 2017 Challenge. Comments are provided in relation to some of the assessment criteria used to judge the Australian team entries (problem definition, model formulation, mathematical processing, model evaluation) with comments both on approaches seen as better, and approaches seen as less good.

Problem definition and model formulation:

Identifying relevant variables. Some factors that were said to be important included: time zone changes; climate; weather; characteristics of the destination city; hours of sunlight; optimal working conditions; and activities outside of the meeting. A key issue then was the extent to which factors said to be important were treated effectively in the solution process.

Better approaches	**Problematic treatments**
Take factors said to be important into account, or specify they are to be ignored for simplification purposes. Recognise that meetings are usually held in climate-controlled buildings. Seek to incorporate climate in recognition of out-of-meeting activities. Use scientific data to optimise working conditions (choose 'best' latitude with defensible definition of 'best').	Fail to take factors said to be important into account. Look for an 'average' climate – ignores that people react differently to their usual climate, to variations in climate, and to shorter-term weather changes. Fail to distinguish weather and climate.

Identifying assumptions, and other factors. A key feature of mathematical modelling is the need to identify assumptions that are made, and to explain why they are made; also to consider how the assumptions made influence the solution found, and how

changing assumptions might affect the solution. Other factors that could be considered include: the difference in jet lag effect between travel towards the east and west; the added impact of travel fatigue; and the possible addition of consideration of cost-related factors.

Better approaches	Problematic treatments
State assumptions clearly and explain why they are made (eg, to simplify the problem). Show how the assumptions contribute to the solution path followed. Consider the possible impact of changing assumptions. Factors used are justified (eg, evidence cited) and linked to solution. Impact on cost of using home location of a participant	Making pointless, unrealistic or unfair assumptions (eg, no flight delays will occur, no crying babies will be on the flight, meeting participants are in good health to minimise health-related exacerbation of jet lag). Factors simply stated with no justification or evidence, and no link to solution. Extensive exploration of flight costs, hotel costs, meeting room hire costs etc.

Mathematical processing

How 'distance travelled' was treated. Some of the considerations that were important here were: considering 'as the crow flies' versus plausible flight routes; whether minimising distance travelled would alone solve the problem; consideration of journey time (for example, whether direct or multiple flights might be needed); accuracy of complex distance calculations.

Better approaches	Problematic treatments
Consider actual flight arrangements (such as proximity to airport, existence of direct flights, total travel time).	Treat all distances 'as crow flies' rather than actual journeys required, including great circle calculations that don't take actual flight routes into account, or using three-dimensional coordinates only. Ignore multiple participants from particular origins.

How time zones were treated. Relevant factors here were: it was essential to use some absolute reference system – most teams used Universal Coordinated Time (UTC) as a reference; the degree of overlap of 'alert' periods for participants; accuracy in calculations of time zones for different locations and different times of the year; and the treatment of 'recovery time'.

Better approaches	Problematic treatments

Seek to minimise the total number of time zone changes for participants. Note that the average UTC offset (or equivalent) does not necessarily minimise total time zone changes. For scenario 1 this criterion leas to UTC8; for scenario 3 UITC4 and UTC2 are equally good. Take account of changes in time zone differences at different times of the year. Quantify the daily period of alertness (and its overlap) for participants (and therefore spell out the impact of jet lag). Recognise that jet lag diminishes each day. One report defined a productivity function, applied it to participants according to their 'normal alert hours', and integrated it to find the total work achieved.	Only time zone considered, without taking account of actual journeys. Time zone calculations performed without checking the total time zone changes that result (eg, note that the 'average time zone' calculation does not necessarily yield the locating with the least number of time zone changes). Ignore multiple participants from particular origins. Ignore the effect of daylight saving on time zone data. Assume the days required for jet lag recovery can be added to the pre-meeting time (contradicts problem statement).

Model evaluation

Sensitivity analysis, solution evaluation. Finally, no modelling process is complete without an evaluation of the solution proposed. Does the proposed solution answer the question? How would a change in the assumptions or starting conditions affect the solution found? What additional factors could be taken into account to make the solution work in a wider variety of circumstances? Very few of the IMMC 2017 reports considered the extent to which their solution was 'best' and what other possible solutions might have been equally or almost as good. Very few teams showed that their solution would apply to completely different scenarios from the two cases given in the problem statement.

Better approaches	**Problematic treatments**
Consider the possible existence of multiple ideal locations. Consider the range of different locations that could provide more or less equivalent solutions.	Find just one proposed city for each scenario. Propose a solution that does not pass the 'laugh test' (eg, clearly looks wrong from inspection of maps provided; is in the middle of nowhere).

Consider the applicability of the algorithm for other scenarios (eg, different kinds of configurations of origin locations – such as several participants coming from a particular region, with only one or two coming from a different region).	